

## CLAIMS

1           1.     A sonic actuator comprising:  
2           a multi-layer membrane including  
3                     a non-metallic elastomeric dielectric polymer layer having a first  
4           surface and a second surface;  
5                     a first compliant electrode layer contacting said first surface; and  
6                     a second compliant electrode layer contacting said second surface;  
7           and  
8           a support structure in contact with said sonic actuator film.

1           2.     A sonic actuator as recited in claim 1 wherein said non-metallic dielectric polymer  
2     is selected from the group consisting essentially of silicone, fluorosilicone, fluoroelastomer,  
3     natural rubber, polybutadiene, nitrile rubber, isoprene, and ethylene propylene diene.

1           3.     A sonic actuator as recited in claim 1 wherein said compliant electrode layer is  
2     made from the group consisting essentially of graphite, carbon, conductive polymers, and thin  
3     metal films.

1           4.     A sonic actuator as recited in claim 1 wherein said support structure is a grid  
2     having a plurality of apertures.

1           5.     A sonic actuator as recited in claim 4 wherein said multi-layer membrane is  
2     biased such that portions of said film bulge at at least some of said apertures.

1           6.     A sonic actuator as recited in claim 5 wherein said multi-layer membrane is  
2     biased such that portions of said film bulge in a first direction at at least some of said apertures.

1           7.     A sonic actuator as recited in claim 5 wherein said multi-layer membrane is  
2     biased such that portions of said film bulge in a first direction at some of said apertures and such  
3     that portions of said film bulge in a second direction at others of said apertures.

1           8.     A sonic actuator as recited in claim 6 wherein said film is biased by a gaseous  
2     pressure that is greater than atmospheric pressure.

1           9.     A sonic actuator as recited in claim 6 wherein said film is biased by a gaseous  
2     pressure that is less than atmospheric pressure.

1           10.    A sonic actuator as recited in claim 6 wherein said film is biased by a soft foam  
2     material.

1           11.    A sonic actuator as recited in claim 10 wherein said soft foam material is a closed-  
2     cell foam with an average cell diameter substantially less than a diameter of said apertures.

1           12.    A sonic actuator as recited in claim 7 wherein said film is biased by a gaseous  
2     pressure that is greater than atmospheric pressure where said film is bulging in a first direction,  
3     and is biased by a gaseous pressure that is less than atmospheric pressure where said film is  
4     bulging in a second direction.

1           13.    A sonic actuator as recited in claim 5 wherein said support structure is  
2 substantially planar proximate to said apertures and wherein said bulging portion of said film  
3 exhibit an out-of-plane deflection.

1           14.    A sonic actuator as recited in claim 1 wherein said multi-layer membrane  
2 comprises a sandwich structure having a plurality of layers of non-metallic elastomeric dielectric  
3 polymers alternating with a plurality of layers of compliant electrodes.

1           15.    A sonic actuator as recited in claim 1 further comprising a square root driver  
2 coupled to said first compliant electrode and to said second compliant electrode.

1           16.    A sonic actuator as recited in claim 15 wherein said square root driver includes a  
2 summer adding a low power input signal to an offset voltage and a square root generator coupled  
3 to an output of said summer.

1           17.    A sonic actuator as recited in claim 16 further comprising a filter coupled to an  
2 output of said square root generator.

1           18.    A sonic actuator as recited in claim 17 further comprising an amplifier coupled to  
2 an output of said filter to provide a signal to drive said multi-layer membrane.